

Sphyrna zygoena and *Carcharinus menisorrhach* are consumed fresh and are generally administered to women after child-birth. Setna¹ (1945) has recorded that shark flesh is at present being filleted and salted in the fish-curing yards all along the coasts of Bombay and Madras. The product is said to find a ready market in the interior. Recently smoking of shark fillets has been undertaken and the process has been found to give a satisfactory product. Even the fins and the tails of the larger varieties of sharks are considered edible when made into soup; formerly large quantities of this material were being exported to England, Germany and China.

The skin of the shark can be tanned to an extremely useful leather³ (1922); at the moment, there does not appear to be any organised attempt in this country to utilise this valuable byproduct. Cameron⁴ (1937) has recorded an exceptionally high content of iodine (1.160 per cent.) for the desiccated thyroid glands of certain fish. The possibility of manufacturing potent preparations of insulin has been suggested; many fish possess pancreatic glands which have been found to contain exploitable quantities of this invaluable hormone. According to Tressler⁵ (1923) various species of sharks have been examined to determine their relative value as potential

sources of insulin. The shark has been found to contain this active principle in a form which can easily be extracted. In these directions, practically no work has been carried out in this country.

We have completed a piece of investigation directed towards the utilisation of the liver residues of the shark as a source of peptones and amino-acids on the one hand, and on the other, of the vitamins of the B-complex, anti-anæmic factors and other physiologically active principles. With regard to the other organs practically no work has been carried out; it is of utmost urgency that work in this direction should be extended immediately; it will serve to lay the foundation for the establishment of a chain of interdependent industries, which together, would contribute towards the stabilisation of the shark liver oil and allied industries.

1. Setna, *J. Sci. Industrial Research*, 1945, 3, 303.
2. Fernandes, *Indian Farming*, 1940, 1, 591.
3. Rogers, *Practical Tanning*, 1922, page 574.
4. Chr. Bomskov, *Methodik der Hormonforschung*, Bd. I, 1937, page 311.
5. Tressler, *Marine Products of Commerce*, 1923, page 693.

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STORAGE OF FOODGRAINS

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IN normal times, the supply and demand for foodgrains and their products could be so adjusted as to entail the holding of minimum stocks for a minimum period of storage. Under conditions of war or of threatened famine, the shortage of foodstuffs in general necessitates the maintenance of large stocks and quite often for longer periods. Even in ordinary times, the storage of food-products has presented many problems in countries where climatic conditions favour generally the deterioration of such materials. This deterioration is usually associated with either a high atmospheric humidity or a high moisture content in the stored product. Humidity and moisture are thus primary factors which control insect attack and mould growth in the stored materials. Besides these, the conditions of storage as well as the conditions in which the grains are received are important factors which determine the loss of foodstuffs in a locality. The problem of storing foodgrains and food-products is thus important requiring close scientific approach for its study. In the present review, it is proposed to summarise the available knowledge on this problem and suggest a simple and practical method for adoption, whereby the loss of foodgrains may be reduced to a minimum.

CONDITIONS FOR STORING FOODGRAINS

Foodgrains such as cereals and pulses have certain fundamental characteristics. In the first place, their moisture content is not a fixed entity but is conditioned by the humidity of the atmosphere in which it may be stored. Thus depending upon humidity, the grains

take up or lose water. According to Snow¹ *et al.*, cereals take up more moisture than pulses (legumes) at a R.H. of 40-80 per cent. Above 80 per cent. R.H., this absorption is reversed. Gane² arrived at similar conclusions independently. The former investigators have, however, recommended safe levels of moisture content for storing different feeding-stuffs. Thus, a moisture content of 15.7 per cent. is the safe limit for short storage of wheat (about three months) while it may be 14.6 for longer periods (over one year). In the case of maize, this safe limit has been fixed at 12.5 per cent. for export purposes. In respect of stored grains, the factor of safety varies to some extent with the different types of products, but broadly it may be fixed at 12-14 per cent. moisture for satisfactory storage, although it could be conveniently lower than this. Secondly, grains with a moisture content of 15 per cent. and above, have a tendency to "heat" up, a feature which is not very desirable, as it affects the quality of the grains. Thirdly, with a moisture content of 15 per cent. and more, conditions are favourable for insects to feed and breed on the material. This is then followed by mould infestation. Wheat, with a moisture content of 17 per cent., has been found to be readily infested by insects, particularly weevils. It must be emphasised here that it is not merely the moisture content of the stored grain, but the R.H. of the atmosphere surrounding the grains is equally important. It is not adequately realised that grains reach equilibrium with the atmosphere and absorb or give up

moisture depending upon the humidity of the air. According to Barton-Wright and Tomkins,³ mould growth was prevented on flour exposed to a R.H. of 79 per cent. and on bran to a R.H. of 75 per cent. during a period of four months' storage. In discussing the influence of humidity on storing feeding-stuffs, Snow *et al.*,⁴ concluded that mould development was conditioned generally by: (1) the R.H. of the atmosphere. (2) The temperature of storage. A humid atmosphere and a temperature of over 20° C. favour strong mould growth. (3) The length of storage period. At a R.H. of 75-100 per cent. mould growth takes place very soon, while below 75 per cent. R.H., the development of moulds is extremely slow though not inhibited. (4) By the type of moulds. In discussing the effect of humidity on insects Germar⁵ observed a mortality of 100 per cent. weevils in two days at a R.H. of 20 per cent. and in twenty-two days at R.H. of 100 per cent.

It is evident from the above that the moisture content of the grain at the time of storage and the humidity of the air to which it is exposed are two essential factors requiring careful control if insect and mould attacks are to be avoided during storage. It may be mentioned here that where grains are treated to reduce their moisture content to 10 per cent. or less, weevils are unable to attack such products, and where they are particularly excluded from air as well, the insects cannot carry on active life. Under such a low moisture content heating of the grains does not take place. Loss of grains during storage is thus avoided. The question of dehydrating grains to reduce the initial moisture content to the safe limit has to be considered both from the view-points of the moisture content of the same as well as the atmospheric conditions during such drying. It is obvious the dehydrated material should not be exposed to a high humidity, as water will be absorbed by the grains. Thus, in Burma, it has been observed that rice milled in the dry season, keeps better than that milled in the wet season. Where the reduction in moisture content is small, heating may be resorted to, since the cost involved is not much. Where the grain is highly infested or where it is otherwise very moist, the removal of moisture by heat may not be a profitable one. Thus, in experiments conducted in W. Indies and Mauritius, the doubtful economy of such a procedure was indicated.

Besides controlling the moisture relations of the grains intended for storage, the successful storage of foodgrains involves in the fulfilment of two other essential conditions, *viz.*, (a) that the produce to be stored is in a condition suitable for storage at the time of introduction into stores and (b) that during the period of storage conditions are established whereby the grains are rendered free from infestation. While it may be possible to treat infested and damaged grains so as to minimise damage, it would be preferable to prevent loss by attention to the provision of suitable stores and to conditions of storage. As a rule, grains are bought in new unused bags in order to

minimise infestation from used bags. But there is no guarantee that the grains are primarily examined or tested for freedom from insect attack. Then again, during transport by rail or carts, infestation is not prevented. A great deal of attention is necessary by the transporting authorities in this connection. This primary infestation prior to storage must adequately be prevented. The secondary infestation takes place during storage.

It is clear from the above that in respect of storing foodgrains, the two essential conditions referred to above must be rigorously attended to. It is known that grains are easily attacked by a large variety of insects, such as grain weevils, beetles, flour beetles, flour moths, mites, etc. It is not proposed to consider the insects except in relation to their habits and behaviour to explain the methods of controlling them. In regard to the first condition mentioned above, where grains are intended to be stored for long periods and in large quantities, it would be wise to screen it first so as to eliminate the adult insects as soon as possible after receipt of the same. The material so treated is in a better condition to store inasmuch as the adults—weevils, etc.—are prevented from laying eggs. The damage resulting from future infestation is largely minimised in this way. The longer this screening is delayed, the greater will be the infestation. In other words, the infestation brought in by the goods to be stored—"the 'incoming' population"—is more easily controlled than the "resident" population, *i.e.*, the infestation during storage. The former treatment is more easily achieved. In cases of heavy infestation, screening the goods followed by dehydrating to the safety level of moisture referred to in the beginning, would ensure satisfactory conditions and render the grain fit for storage. In this connection, the question of treating containers like gunny bags, in which grain is normally transported, is a very important one. These should be sterilised either by dry heat, sun or by the use of boiling water, before being used again. The rooms wherein the bags were stored with the grain, should be well cleaned and fumigated.

In the matter of storing grains free from insects, this is largely achieved by adhering to conditions of hygiene and to selection of proper storage containers, such as bins for bulk storage. These must be free from holes, crevices, angles, etc., wherein insects reside largely. These bins are capable of being fumigated and sprayed with chemicals, after the contents have been removed. They are capable of being closed airtight so as to prevent contact with the outside air. It is common knowledge that grain weevils and moths thrive best in darkness and in a still, warm atmosphere. Therefore good light and thorough ventilation are generally recommended for storing grains in bags. These are elementary precautions in the storage of grains. When the bins are cleared of their contents, all rubbish and refuse from the stored product should be swept up and completely destroyed. It is not uncommon that such refuse grains are often taken back to the stores just to avoid report of loss on

storage. This dangerous practice cannot be justified on any account. The regular movement of stored grains also acts as a check on the multiplication of moths and weevils. The mixing of fresh stock with that in storage should never be recommended without thoroughly examining both for freedom from infestation. The question of containers for long storage is engaging the attention of authorities in this country and is outside the scope of this article.

THE CONTROL OF INSECT PESTS OF STORED GRAINS

In actual practice, the enforcement of the conditions referred to previously, leaves much to be desired, so that infestation of grain by insects and subsequently by moulds has not been eliminated either prior to storage or during storage. In this country, storage of grains is generally in bags and it is only now that the different governments are planning to adopt bulk storage in bins, etc., and control infestation by long-established methods in vogue here and abroad. Infested grains have been subjected to physical treatments such as heat, X-ray, etc., on the one hand, and to fumigants on the other. The former procedure has not been of much avail because of the cost involved in "de-weevilising"* and in reducing the moisture content of infested materials, which are highly moist—the greater the degree of insect attack the greater is the moisture content of the grain. The employment of fumigants has been widespread and much literature has grown on these. Beside these two processes, a simple method of coating grains with certain "inert" dusts has recently been evolved—more in the nature of a prophylactic or protective treatment than a curative one, which the other two are.

In treating infested grains, the degree of infestation is the most important factor, so that each bag or bin must be closely examined by a competent technical staff. In very incipient stages of infestation or where infestation has just commenced, it may be wise to screen the material and subject the residue to a high temperature for a short interval, or *vice versa*. Considerable care is necessary, where heat treatment is to be resorted to. Normally, the ryot exposes the grains to the action of sun's rays for a day or two, winnows the material and stores again. In this way, he is partially dehydrating in addition to removing the insects. Where larger quantities are involved, some form of commercial dryer is needed. During the last War, a mechanical equipment—known as Hess Dryer and Cooler—was evolved in England to process infested grains. In this drier, the infested grain was reconditioned, improved and further damage prevented by subjecting such material to a blast of hot air followed by one of cold air, the grain being dried in this process, most of the mites killed and their bodies recovered. In the Hess Drier and Cooler,⁶ "the grain is passed from a band conveyor into a garner where it falls into a chamber containing a series of horizontal racks arranged one above the other, zig-zag fashion. After subjecting it to a hot air blast, the wheat

passes into a similar chamber and receives a blast of cold air, then it passes into a hopper beneath and thence is discharged on to a band conveyor. Cold air is drawn through the lower chamber by a powerful fan, is forced over a series of steam coils and then passes over the wheat in the upper chamber". Here heat serves as a sterilising agent, the temperature recommended not exceeding 150° F. which does not affect the quality of the grain. It is never advisable to go above this temperature which is fatal to all insects. This method had been in vogue in U.S.A. and in Australia. The difficulty is one of adequate equipment and the possible repetition of heat sterilisation more than once, should reinfestation set in during storage. In high temperature treatments, the difficulty is again to decide upon the range of temperature non-injurious to the grain but fatal to the contained larvæ. Generally 140° F. is enough to kill all insects but five minutes' exposure to a temperature of 125° F. is just as fatal. For seeds, a temperature of even 150° F. does not affect germination. It is probable that higher temperatures would impair the quality of the grain, affect the baking quality in the case of flour from wheat. In the highly moist condition, depending upon the degree of infestation, denaturation of the proteins cannot be eliminated. Again, the heat treatment has to be carried out when the outside temperature is high. Although heat treatment of grains has not been generally favoured, it may be mentioned here that recently the application of electronics or high frequency current to processing grains has been reported. It has been observed that a temperature of 120-130° F. is easily attained by a 3 kw heater and an exposure of 20-30 seconds seems to be more than adequate for the purpose. The equipment for this process is also less complicated. The generation of high frequency current of at least 100,000 cycles would be required. It has further been observed that the cost of this process is mainly that of generating this frequency.

CONTROL THROUGH FUMIGATION

The only radical method of ensuring freedom of grains from pests is sterilisation, i.e., subjecting the grains to the action of a lethal agent. Although a fumigant is not a lethal agent, the difference between the two is very small. Both should, however, not impair the quality and flavour of the material treated. A fumigant does not affect the grain, but must possess good powers of penetration, be non-inflammable and be without harmful effect on the operators. It is essentially a chemical process and has been favoured all the world over. In the selection of a fumigant, the following conditions are essential. Primarily, the fumigant should be violently toxic to insects only. It should be easily and cheaply generated and should not readily condense to a liquid medium. It should have great powers of diffusion and be insoluble in water as far as possible. The vaporization of the fumigant is the most important factor to render it thoroughly effective. The main cause of failure of fumigants is traceable to the sorption of the same either by the stored product or in the walls of

* This expression is employed to connote the removal of insects in general.

the fumigation chamber, whereby a large part of the vapour is rendered inactive. Hence ample allowance must be made for this sorption. What is sorbed by the foodgrain has little or no insecticidal effect. Therefore, the lethal concentration effect of the fumigant must be maintained after allowing for this factor. This aspect of the problem has recently been considered by many investigators. It is necessary to refer to the article of Oxley and Rowe⁷ in this connection. Ordinarily, the atmospheric concentration around the insect is more important for practical purposes than the amount employed or taken by the insect. Thus according to Winteringham,⁸ "in fumigation practice, the dosage of a fumigant required has often to be found by trial and error. Available data frequently express dosage in pounds per 1,000 c.ft. of chamber, which means that the dosage is based on the capacity of the chamber alone and does not allow for variation in the proportion of the fumigant sorbed by the product treated. This proportion is considerably affected by such factors as the nature of the product fumigated and temperature. The proportion of the fumigant sorbed by the product is sometimes very large. For example, during the fumigation of 140 lbs. bag of wheat feed with ethylenedichloride in a 500 L chamber, no less than 90 per cent. of the fumigant was sorbed by the wheat-feed, leaving only 10 per cent. available in the free air space for killing any infesting insects. The data obtained on the sorption of ethylenedichloride by various products have enabled dosage and distribution of the fumigant in the sorbed state to be estimated and have provided certain information about penetration, aeration and the nature of the residual fumigant". The higher the quantity of the fumigant sorbed by the feed, the larger the time needed for removing the same. Besides these, the successful fumigation of a product in practice, requires that (1) the bins or other containers employed must be capable of being closed tight; (2) the product must be warm enough, preferably at a temperature of 70-75° F. Better results are reported at 85-90° F.; (3) the bin doors must be sealed air-tight; (4) the fumigant should be applied by removing it from the original containers; (5) it is best to cover with a tarpaulin or with sacks, the surface of the product to be treated; and (6) the breathing of an excess quantity of the fumigant should be avoided. These are public health regulations requiring handling and manipulation by a technically trained staff. In this way alone, the hazards incidental to fumigation are minimised, if they could not be eliminated altogether.

Several fumigants have been in use. HCN gas or cyanides (6),^{*} Carbontetrachloride (1/10), Carbonbisulphide (1), Ethyleneoxide (3-5 1/2), Ethylenedichloride (1/4-1/3), Chloropicrin (2 1/2-3), Methyl Bromide (7), Methyl and ethyl formates (1/4), Trichloroacetonitrile, have been recommended as fumigants. According to Shafik,⁹ the order of toxicity of the

fumigants together with minimum dosage (in c.c. per litre) for a 100 per cent. kill is as follows: Isopropyl chloracetate 0.008, Methyl chloracetate 0.01, Ethyl chloracetate 0.02, Ethylenedichloride and CCl₄ mixture 0.05, Ethylenedichloride and Trichlorethylene mixture 0.18, Ethyl formate and CCl₄ 0.10, CS₂ and CCl₄ 0.14, CCl₄ 0.18, and Trichlorethylene 0.18. It will be seen from the above that a mixture of ethylenedichloride and carbon tetrachloride has been recommended and widely adopted. This mixture has all the good effects of an ideal fumigant mentioned above. The literature on fumigation is extensive and the following summary of the existing knowledge is included here.

The type of insects infesting grains is varied and includes moths, weevils, beetles, etc. Apart from this, we have to deal in each case, with the eggs, pupæ, larvæ and adults. One encounters in infested grains, at one and the same time, insects at all stages of development. Hence the fumigant employed must be effective equally on all the stages—which is unfortunately not the case. The action of fumigants on insect varieties also varies as can be seen in the following table:—

Median lethal conc. of fumigants for the confused flour beetle and the grain weevils:

Temp. 25° C. Time of exposure 5 hrs.

Fumigant	<i>T. confusum</i> Flour beetle	<i>S. granarius</i> (Granary weevil)	<i>S. oryzae</i> (Rice weevil)
Hydrocyanic acid (HCN) ..	0.6	5.8	-
Chloropicrin ..	4.6	5.0	2.0
Methyl Bromide ..	11.2	7.6	4.0
Ethylene oxide ..	18.0	5.6	5.7
Methyl formate ..	23.5	20.0	-
Ethyl formate ..	24.5	25.0	17.5
Ethylene dichloride ..	37.5	38.0	31.0
Carbonbisulphide ..	61.0	40.0	26.0
Ethylacetate ..	83.0	86.0	49.0
Trichlorethylene ..	108.0	335.0	196.0
Carbontetrachloride ..	185.0	360.0	160.0

(Expressed in mgs./L to effect 50% mortality)

From the data presented above, it is obvious that the toxicity of a fumigant varies in quantity from one kind of insect to another. The granary weevil is more resistant to fumigants in general than the rice weevil. These figures were obtained with commercial fumigants and are only relative. According to Shepard et al.,¹⁰ two closely related species like *S. granarius* and *S. oryzae*, are likely to "show the same relationship of toxicities throughout a considerable series of unrelated compounds."

Even in the same insect, the egg stage is commonly believed to be more resistant to a fumigant than other stages. Also a particular insect stage may be more resistant to some fumigant than to others. There is, however, no correlation between the respiration rate of insects at particular stages and a fumigant as is commonly thought.

* The figures in brackets refer to dosage needed on the basis of carbondisulphide as one unit according to an Australian worker.

Median lethal conc. of certain fumigants on different stages of the flour beetle. Temp. 25°C.

Fumigant	Egg	Larva	Pupa	Adult	
				Young	Old
Carbonbisulphide	147	60	136	110	63
Chloropicrin	45	3.5	9.1	4.3	4.4
Ethylene oxide	2	11.0	19.5	—	18.0

Here the adults are killed at about half the dosage of CS₂, or about $\frac{1}{10}$ the dosage of chloropicrin needed to kill the eggs, but they are 9 times as resistant as the eggs to ethylene oxide. Thus the fumigant effective against adults or larvæ may not be useful for killing the eggs. Also, the egg stage of certain insects may be more resistant to some poisons yet less so to others.

Further, geographical location is a factor operating likewise on insects, according to Lindgren and Shepard.¹¹ Apart from this, each stage of the insect differs in susceptibility at different periods of development. These specific differences in susceptibility to a fumigant are normally due to the differences in fatal dose but it is also possible that one species of insect may sorb more fumigant from a low concentration, while a second one may sorb from a higher concentration. Thus, rice weevils relatively resistant to HCN sorb only 0.444 mg. per gram of body-weight from a conc. of 77 mgs. in 10 mins. The question, therefore, is one of ready sorption of the toxic fumigant by a species of insects.

In recommending this method of treating infested grains, greater consideration must be given to hazards arising from the use of such toxic chemicals. Primarily, the human skin absorbs almost all the chemicals as shown by McCord.¹² It is also pertinent here to refer to the work of Wirtshafter and Schwartz,¹³ reporting acute ethylenedichloride poisoning. It is, however, possible to overcome fire hazards in a suitable manner, such as diluting the fumigant with a noninflammable material like CCl₄. But the more important fact is the "residual" effect or sorption of the fumigant by grains and other food products. It is well known that only a certain quantity of the fumigant can exist as vapour without exerting pressure on the walls of a chamber or bin. In order that a fumigant may act on the insect, the atmospheric concentration around the insect is more important than the amount taken by the insect itself. Humidity also plays a large part in this. The sorption of a fumigant is about eight times that without flour or other absorptive material. It may be roughly stated that the higher boiling fumigants are most highly sorbed.

Where the fumigant is sorbed both by the stored product and by the insect in large amounts, the quantity of the fumigant necessary to maintain the lethal concentration in the air around the insect will be much more than what has been reported till now. This point has been stressed by Oxley and Rowe

Sorption ratios for various fumigants in presence of flour (Temp. 25°C.)

Fumigant	Lethal Concentration in mg./l.		Sorption Ratio	B.P. °C.	Vapour pressure mm. 25° C.
	No sorbent	Flour			
Methyl bromide	10.2	21	2	4.5	760
Ethylene oxide	15.5	96	6	11.0	760
Hydrocyanic acid	—	—	2	26.0	739
Methyl formate	18	78	4	32	—
Carbon disulphide	64	147	2.5	46	361
Ethylene dichloride	46	240	5	84	80
Chloropicrin	3.9	35.5	9	112	24
Tetrachlorethylene	54	440	8	120	—
Methyl thiocyanate	1.4	16	10	130	—

(loc. cit.). According to Winteringham, in a bag of 140 lbs. wheat, to secure a final concentration of 62 mg./L. of ethylene chloride in the free space, 455 grams of the fumigant for a 500 L chamber were needed for an exposure of 48 hours at 20° C. Similarly, for a bag of 100 lbs. in order to maintain a conc. of 36 mg./L, 58.5 gms. of the same fumigant were required. The conditions influencing the sorption of a fumigant also vary. Thus the lower moisture content of the grain, the less is the sorption of the fumigant. The quantity of ethylenedichloride sorbed by one variety of wheat is reproduced as read from the graph of the paper by Winteringham (loc. cit.).

Sorption of Ethylenedichloride (p.p.m.)

Conc. of the fumigant	Time in hours		
	24	48	168
10 mg./L.	150	200	250
100 mg./L.	1750	2000	2600
200 mg./L.	3600	4000	5600

The only advantage in using ethylenedichloride mixture is, in the opinion of Shafik,⁷ that it could be used safely for fumigating materials with a high water content, i.e., in a heavily infested condition, or "in places where free water content cannot be excluded". In the opinion of others, "these mixtures are, however, unstable and not satisfactory". They are all fat solvents and so are not suitable for fatty materials.

p-Dichlorobenzene is a good seed disinfectant but it leaves a taint in the grain which does not, however, affect germination.

In fumigation practice, it is safe to provide gas masks for the workmen. First Aid provisions must normally be available.

PROTECTIVE COATING WITH INSECTICIDAL DUSTS

The employment of protective dusts for storing grains free from insect pests is an alonging practice in various countries. Slaked lime has been used to the extent of even 5 per cent.

on the quantity of foodgrains. Chalk powder at the rate of 1 per cent. by weight, has also been used. Very fine dry soil has served more effectively in India and other countries. The protection afforded in many cases may merely be mechanical, in that the grain is covered and hidden from attack. The interest in the use of dusts has recently been aroused by the application of a large number of "inert" dusts including magnesia, silica as mentioned by Peters.¹¹ The availability of finely ground quartz, as a proprietary product "Naaki" aroused further interest in England and other countries. Zacher¹⁵ suggested that the dusts acted on the insects as a desiccant. Chiu¹⁶ reported the action of silica on the bean weevil in relation to particle size. These dusts have no effect on the physiology of the insect such as clogging the spiracles. But all the insects were found to clean their bodies vigorously with legs, mouth-parts and antennae. If the killing of the insects was a desiccation process, it is natural to suppose that they would be most effective at low humidities. This was shown to be the case, by Germar. In his experiments, a mortality of 100 per cent. of the granary weevils was observed in two days at a R.H. of 20 per cent.; in three days at 45 per cent. R.H., in seven days at a R.H. of 80 per cent., while at 100 per cent R.H., it took 22 days for the insects to be killed. The temperature was 25° C. Apart from mere desiccation, the action of the dusts may be due to an irritation of the intestines. In Egypt, a product known as "Kattelsousse" prepared from ground rock-phosphate and sulphur has been sold by the I.C.I. on behalf of the Egyptian Government. This material has been used at 1 per cent. on the weight of the grain. Narasimhan and Krishnamurti¹⁷ reported the use of scorched paddy husk for the same purpose. The ground husk was passed through 100-mesh and has been effective in controlling the insects.

In the last three years, considerable advance has been made in respect of the use of these dusts. Briscoe and co-workers¹⁸ from the Imperial College of Science and investigators such as Parkin¹⁹ from the Pest Infestation Laboratory, have tried to explain the various factors such as particle size, method of preparing the powders from different sources. The efficacy of a mineral dust may be correlated with the particle size secured from hard substances ground in the wet condition or in a micronizer, approaching that of colloidal and retaining simultaneously the microcrystalline or angular surfaces, which are lost by dry grinding. They have used the powder at 1 per cent. on the weight of the foodgrain but a lower percentage is possible. Less hard materials like gas-mask charcoal have also been successfully used in their studies.

As for raw materials, they select one with a hardness of over 6, on the Moh's scale, i.e., harder than Pyrex glass. Carborundum is available in England and has been widely experimented with. It is costly. The cheapest material has been featured from power-house clinker fired by mechanical stokers. Feldspar is equally good. Silica in any form has to be discarded, being a source of silicosis. The search

for cheap substitutes like paddy husk ash (?), has been successful, but it may not be quite well known that the scorched husk contains over 90 per cent. of the ash, as free silica. Railway clinker and similar materials had been tried by the writer successfully.

The most important factor in this project, is the size of particles of the powders used to coat the grains. The finer the particles, the greater is their adhesion to the grains and insects. It has been ascertained that a particle size above 20 μ does not stick to the grains. When the particles are about 1 μ , agglomeration of the same takes place, although adhesion is maximum. Such powders, when employed at 1 per cent. basis, give a very thick coating both on the grains and on insects. Chiu¹⁶ correlated the action of crystalline silica against been weevils as follows:—

Diameter of particles in microns		Days required to kill	
Range	Average	50%	100%
1-147	2.9	1.8	5.0
1-149	18.8	4.2	10.0
10-74	37.5	10.5	18.0
74-149	111.0	14.5	20.0

It may be pointed out here that particles above 20 μ are not considered effective. The maximum effect has been observed with a particle of 1.8-2 μ . In practice, particles ranging from below 15 μ are quite adequate for general use. In one of the trials, the distribution of particles in a carborundum powder has been reported as follows:—

under 1 μ	0.1%	between 5-7 μ	32.0%
1-3 μ	10.0%	7-9 μ	21.0%
3-5 μ	29.0%	Over 9 μ	8.0%

The distribution of particles in a given powder must be estimated by established methods such as those of Goodhouse.²⁰ But it must be cautioned here that "size classification by sedimentation in water is usually undesirable." The production of such fine powder is easily effected in commercial ball mills. The method of grinding influences largely the effect of the dust. While dry grinding may be quick and yield very fine powders, it had been ascertained that such powders had not the same effect as those ground wet. In grinding, the nature of the liquid is immaterial. This difference between dry and wet grinding is large in the case of clinkers, quartz, magnesite, etc. Where dry grinding has been effected, it was observed that treatment with hydrofluoric acid improved the effect of the dusts. Where the same could be secured in the precipitated condition, the activity was quite efficient. One of the most important aspects of the dusts treatment is that the powder intended for use must be kept dry, although it does not absorb water. The effect on the insect is one of desiccation without itself absorbing any water. Dusts differing greatly in chemical composition, but of similar composition show comparable effectiveness.

The influence of R.H. on the dusted grain is an important aspect. Thus at 100 per cent.

R.H. the mortality was hardly 1½ times that of the control, while at 90 per cent. R.H., this activity rose to three times that of the controls. The work of Germar had already been referred to earlier.

In summarising the above, it may be mentioned that the process of coating grains with dusts is a simple one and consists merely in the mixing of the same with a definite quantity of the fine powder in a suitable equipment. This method can be used both for cereals and pulses. The general opinion in respect of eliminating the dusts, prior to milling, etc., is that it presents no difficulty. Moreover, many of the dusts are innocuous to the alimentary tract. The treated grain may be stored in closed containers so as to avoid exposure to atmosphere and to changes of weather. The coating of grains with dusts to control insects in stored products is, therefore, recommended for the following reasons. In the first place, it protects healthy grains from insect invasion. Secondly, the infested grains containing both the adults and larvæ are rapidly freed of these destructive agencies being desiccated and finally killed by the dusts. It may be mentioned here that the age of the insects is a factor, the young larvæ being more susceptible than the adults. The treatment is effective with regard to the existing population, in retarding oviposition and hence prevents reinfestation. The pupæ emerging from the eggs are rapidly killed by the dusts. Thirdly, the ray materials for these dusts are plentiful and the choice is very wide for selection for cheapness. None of them need be imported from abroad, as is the case with fumigants. The example of Egypt is worth emulating in this respect. The equipment for the production of such fine powders can be rigged up in each province, the same being very simple in character and construction. There is no harm introduced by these dusts, as is probable with fumigants. Finally, the process is economically practicable from the view-point of cost and ease of application.

The quality of the grain so treated is in no way affected. Only the treated grain does not flow as readily as the dry fresh grain, but this is no serious defect, if it is remembered that the highly infested grain does not also flow readily.

A PRACTICAL METHOD FOR TREATING GRAINS TO STORE THEM

The following suggestions are thus made for practical adoption. The grain as received, is first sieved in a vibrating screen, whereby the

adult insects are removed. Where the infestation is heavy, such grains may first be passed through a screw conveyor fixed in a jacketed galvanised iron trough, heated in a suitable manner. In this way, the dehydration of the grain is also effected. This is then screened. The clean grain is next mixed with the dust, which may vary from 0.3 to 1 per cent. on the weight of the grain depending upon the efficiency of the dust selected. The mixing may be done in drums, in various places, prior to storage in bins or granaries or other containers which may be capable of being closed fairly airtight. Such containers can also be of plaited bamboo, earthen structure, cement concrete and the like. These containers should be protected from destruction by rats. For this purpose, these are raised more than 3 feet high from the ground, standing on logs which are provided with 4-inch iron-sheets protruding outside around the bottom.

The author had been interested recently in the processing of a cheap clinker and a non-siliceous material and could supply adequate quantities on demand.

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PITHECANTHROPUS IN PEKING

IN reviewing the work of Weidenreich on *Sinanthropus*, Prof. W. E. Le Gros Clark seeks to establish that there is no justification for a separate genus *Sinanthropus* (*Antiquity*, XIX, 73). In this view, he is supported by Prof. Ruggles Gates who holds that *Sinanthropus pekinensis* should, according to the rules of biological nomenclature be called *Pithecanthropus pekinensis*. *Pithecanthropus* and *Sinanthropus* are related to each other in the

same way as two different races of present mankind. The Java Man possessed essentially human palate and dentition and also quite human limbs and erect gait. From this probably arose the generalised Neanderthaloid type, which diverged in two directions, one of which led to the specialised European Neanderthal type of the later Mousterian date, and the second through Acheulean man to *Homo sapiens*.